Long Life Hollow Cathodes for High Power NEP Missions

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Hollow cathodes are a critical component of most electrostatic and Hall effect ion thrusters. The record life of a hollow cathode was the Space Station plasma contactor test run at NASA/GRC. During this test, the cathode performance changed after 23,000 hours of operation, and the cathode finally failed to restart after 28,000 hours, or just over 3 years. This endurance is impressive, and exceeds almost all demands on a hollow cathode for solar electric propulsion missions. However, on nuclear powered spacecraft to the outer planets, electric thrusters will be required to operate for more than 5 years. Because of this need, we have begun a systematic investigation to model the processes that can cause hollow cathode performance degradation and failure.

First we have investigated what caused the Space Station plasma contactor to fail to start after 3 years. We will present a model of the insert region barium chemistry that shows that simple barium depletion was the probable cause. This model is an extension of the 1-D model of Koveleski (IEPC 01-276) that includes the barium-plasma chemistry. The result of barium ionization is to increase the rate of barium and barium oxide.

Second, we have modeled the insert region plasma, including electron impact ionization of Xenon atoms, and resonant charge exchange collisions between xenon ions and atoms. The electron temperature from this model agrees well with measurements by Malik, Montarde, and Haines (J. Phys D **33**, pp. 2307-2048, 2000). In contrast to previously published theories of hollow cathode operation (Salhi & Turchi, IEPC-93-024), the new model predicts relatively little heating of the cathode insert by ion bombardment.

Finally, we have a new 1-D model that extends the previous model of the insert region (Katz et. al., JSR 34, pp. 824-828, 1997) to include charge exchange collisions, a radial density profile, and axial variation in all parameters. The model shows that the axial variation of ion currents to orifice walls is in agreement with published shapes of orifice erosion (Polk, et. al., AIAA 99-2446).